Vol. 2 JULY, 1923 No. 7

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published Monthly by the American Welding Society
33 West Thirty-ninth Street, New York

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Vol. 2 July, 1923 No. 7

At the request of the Sections, the Officers of the Society have instructed the Meetings and Papers Committee to cooperate with the local sections in arranging their programs for the coming year. In order to be able to render help to the best possible advantage the Meetings and Papers Committee, after careful consideration, decided to solicit the advice of the members of the local sections. Obviously the best way the attendance at section meetings can be increased is to arrange programs that appeal to members of the particular section concerned. Accordingly the letter given below was sent out as a starter to the members of the New York Section. The questionnaire referred to in the letter is also reproduced. Similar letters will be sent to other sections of the Society in the very near future. The Meetings and Papers Committee can render the most efficient service if they are guided by the wishes of the members of the local sections. Your interest in welding may be measured by the promptness with which you fill out the questionnaire.

Dear Sir:

This is a short heart-to-heart talk with you about the New York Section of the American Welding Society and your part in making the meetings successful.

The first fact staring us in the face is that members don't turn out. WHY?

Welding and cutting are rapidly becoming indispensable processes, in manufacturing as well as repairing. Five years from now we should be one of the l a r g e engineering Societies. Everythnig points toward the elimination of old-time, slow, costly and inefficient methods of construction; that means welding will come to the front.

Is the American Welding Society going to the front also? It is if you will come out and take your part.

Mr. E. H. Ewertz, General Manager of the Bethlehem Shipbuilding Corp'n, Moore Plant, is our Chairman for the coming year. He has undertaken to serve in that capacity at no inconsiderable cost of time and labor. Will you back him? We are sure you will, especially if the subjects of papers and discussions are of interest and value to your own business. Will you help to steer us during the next year by filling in and returning the enclosed question sheet?

We are planning to arrange the entire program for next year sometime within the next month and therefore need your cooperation by a prompt reply.

Very sincerely yours,

A. G. Oehler
C. J. Holslag
F. E. Rogers
W. Spraragen.
Meetings and Papers Committee.

QUESTIONNAIRE

1. What subject or subjects are you interested in which if scheduled will insure your attendance.
2. Have you any suggestions as to how the meetings should be run?
3. Will you deliver a paper yourself or will you participate in the discussion?
4. Are you interested in repair jobs?
5. Are you interested in the applications of welding and cutting in manufacturing work?
6. Would you like one or more dinner meetings at cost at $1.50 per plate?

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the Bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

A-18.—Experienced Oxy-Acetylene Welder, Class C Member of the American Welding Society, desires position. Nine years' all around experience in welding and machine shop.

POSITION VACANT

V-II.—Welding supervisor wanted. Must be thoroughly familiar with all processes of fusion welding and its application in railroad shops.

WELDED PRESSURE VESSELS

For several years efforts have been made to draw up a Code for the Welding of Unfired Pressure Vessels. Opinions of the best welding experts were not in agreement on many essential points. Fundamental scientific knowledge based on test data was not available. The American Bureau of Welding has completed a series of tests on some 47 tanks. The program involved an expenditure of over $15,000. The test data, analysis of same, conclusions and recommendations to the Boiler Code Committee of the A. S. M. E. have been compiled in a report, copies of which are available for distribution at $1.50 to members and $5.00 to non-members.

AMERICAN WELDING SOCIETY
33 West 39th Street
New York, N. Y.

ARC WELDED CAST IRON ENAMELED WARE

By O. H. ESCHHOLZ*

The most frequent defects encountered in thin, 1/8" to 5/16", cast iron structures for enameled ware are small holes and weakening cracks. These may be repaired in most cases by employing the metallic electrode arc welding process and either cast iron or steel electrodes.

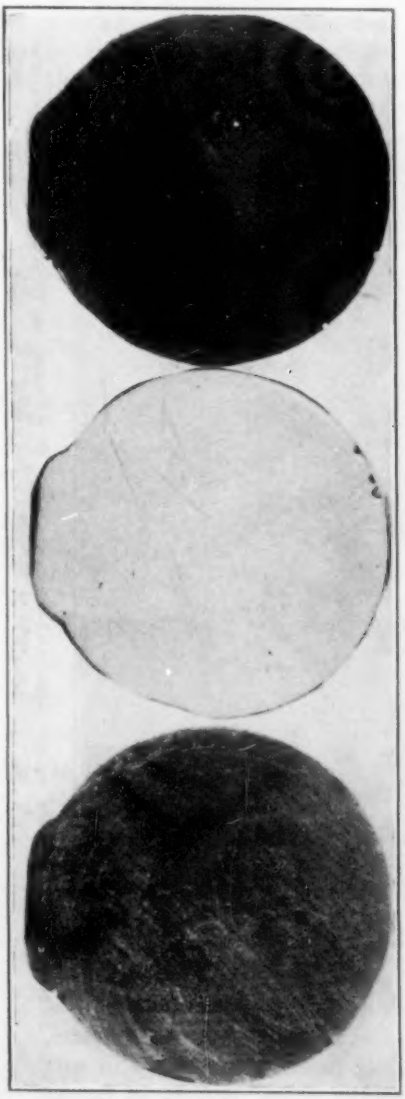


Fig. 1—Built up deposit (at top) and ⅜" hole in a 2½" cast iron disc welded hot with covered cast iron electrodes and surface A enameled. No cracks and very few gas pockets, thinly enameled surface satisfactory.

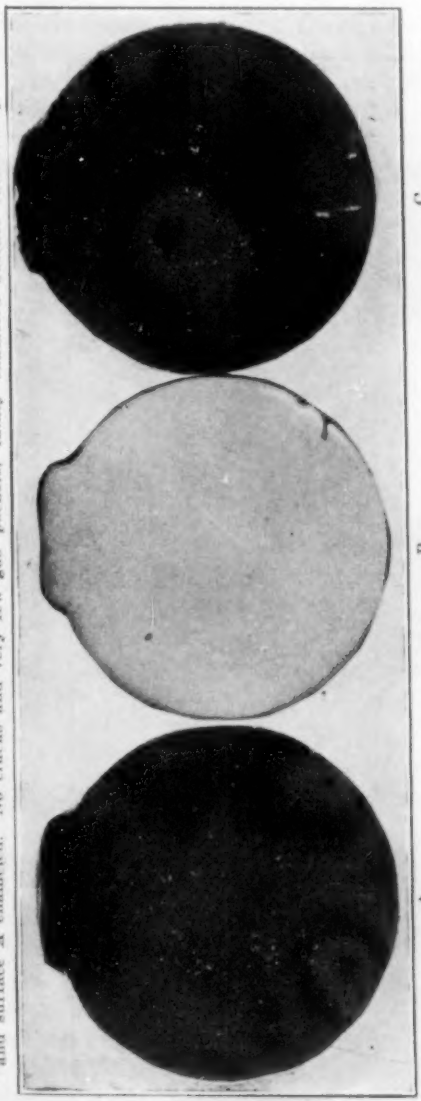
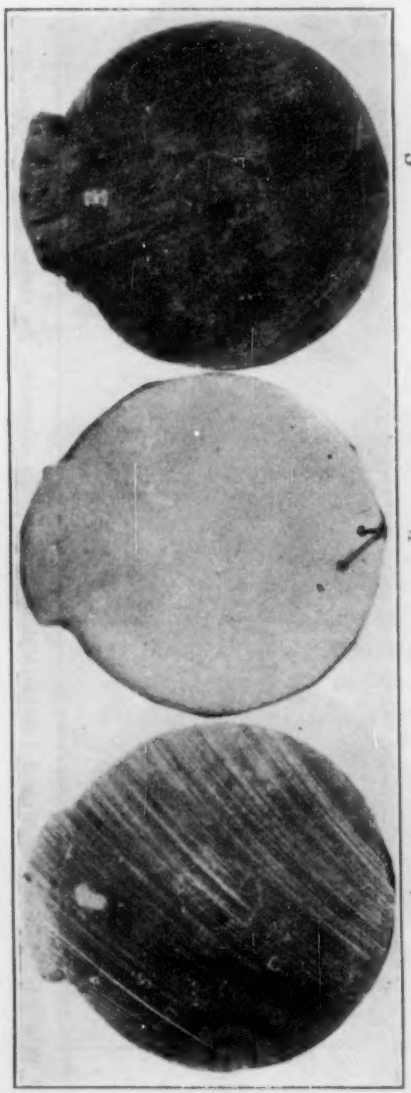


Fig. 2—Cast Iron Disc Welded Cold with Covered Cast Iron electrodes. No cracks but gas pockets—thin enamel surface shows pits.

* Westinghouse Elect. & Mfg. Co., East Pittsburgh, Pa.

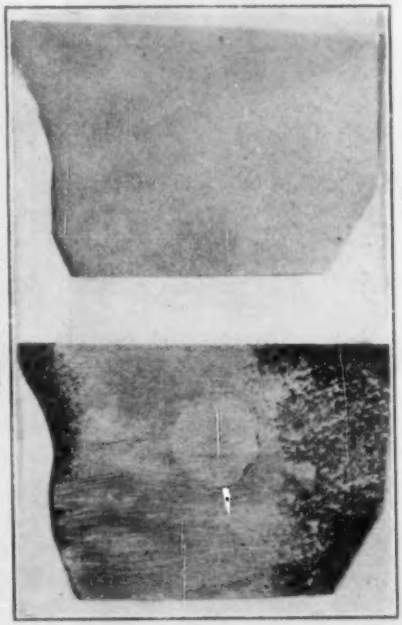
Cast Iron Electrode Welding

The best results will be secured by preheating the casting locally or entirely to a moderate temperature and welding the defect with coated cast iron electrodes. To illustrate the appearance of welded surfaces before and after enameling, ½" holes in cast iron discs 3/16" thick and 2½" in diameter were filled and part of the perimeter built up, as in Fig. 1. A and B of this figure show, respectively, the appearance of one face of the disc after welding *hot* with *coated* cast iron electrodes and after the application of a thin



A B C

Fig. 3—Cast Iron Disc Welded Cold with Bare Steel Electrodes. Line of demarcation of metals visible through thin enamel coat.

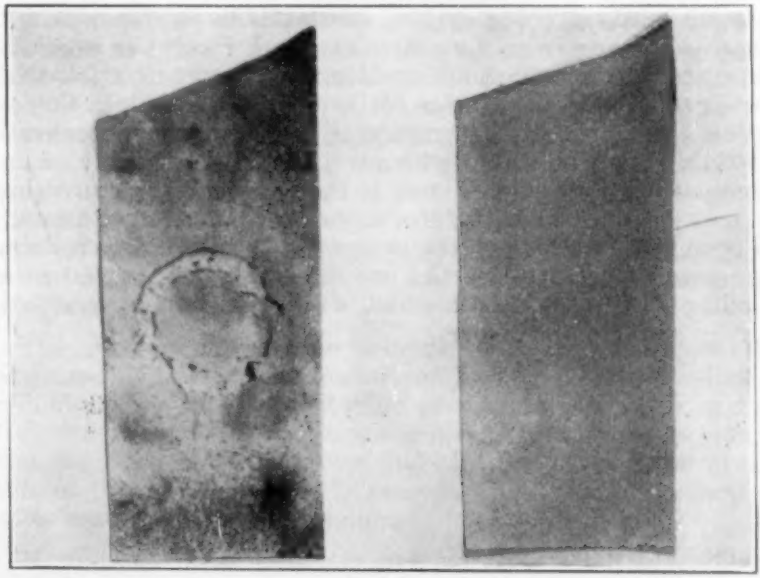


A B

Fig. 4—½" Hole in Cast Iron plate welded with steel electrodes, line of demarcation concealed by a commercial coat of enamel.

enamel. Fig. 1-C shows the rear after the enameling operation. It may be observed that no cracks or appreciable gas pockets are present either on the filled in or built up areas and that the welded zones cannot be detected through the thin enamel.

While the advantageous features of preheating and annealing of cast iron are generally recognized, experience has shown that such treatments are frequently of minor importance in welded enameled ware, particularly when the economies secured by their omission are considered. In Fig 2 is shown a disc that has been welded *cold* with *coated* cast iron electrodes. Both the front and rear faces, Figs. 2-A and 2-C, show the absence of cracks but with the presence of quite a number of gas pockets. A few of the latter may be recognized on the thinly enameled surface shown in Fig. 2-B. Since in the commercial product a "slush" or proming coat is applied to fill up surface irregularities it is felt that pockets of this order will be effectively concealed.



A B

Fig. 5—1¼" Hole in a Cast Iron Plate plugged with a cast iron disc and welded around perimenter with steel electrode. Note formation of weakening cracks and their visibility through the enamel.

Steel Electrode Welding

Despite the well-known difference in the coefficients of expansion of low carbon steel and cast iron, considerable success has accompanied the use of bare mild carbon steel electrodes. Although the line of demarcation between the cast iron and arc deposited metal is usually quite evident, objectionable structure weakening strains do not appear to develop in welded holes having a diameter less than about one inch. The division between the two metals is

shown in Figs. 3-A and 3-C and is still apparent through a thin enamel coat in Fig. 3-C. However, this line disappears from view with the increased opacity secured on a commercial enamel as in Fig. 4.

On welding holes exceeding one inch in diameter with bare steel electrodes contraction strains, on cooling, may cause the development of radial, circumferential or tangential cracks. It has been proposed to avoid these by plugging the hole with cast iron and then welding around the perimeter, but, as shown in Fig. 5, this does not appear to be the solution. Somewhat better results may possibly be secured by puddling the cast iron disc with a carbon arc or with steel electrodes. To reveal structure weakening cracks on doubtful applications the welded and ground surface should be etched with a dilute acid.

Development

The arc welding of enameled ware has received little intensive study, the process being applied substantially as it has been developed for other uses. By controlling such factors as preheating temperature, electrode choice, welding procedure, it is felt that a considerable margin exists for further improvement. In this connection, it is interesting to note that by utilizing the localization of welding energy secured with arc processes the repair of completed enameled structures, such as the welding of fractured bracing bars on finished bath tubs, is practicable. Notwithstanding the present limitations of the process, it is possible to reclaim a large number of castings. At one plant as many as 150 pieces, including bath tubs, kitchen sinks, wash bowls, etc., are repaired daily by a single arc welder.

PRODUCTION WELDING OF SHEET STEEL BY THE OXY-ACETYLENE PROCESS†

By J. L. ANDERSON*

The fabrication of sheet metal into vessels, containers, and receptacles of various forms, and for innumerable purposes, progressed through the stages of soldered, riveted, and locked seams. See Fig. 1. All were more or less unsightly, and the application of special finishing processes was limited, due to the inability to finish the seam in keeping with the other portions of the article. The dimensions of such products had to be kept within narrow limits, due to lack of strength and dependability of the seams and joints, unless made excessively heavy.

The goal to which many manufacturers looked, was the ultimate stamping and drawing of their product, to overcome the difficulties and limitations due to seams, but this was prohibitive, until a reliable market had been created for their product and the possible continous demand warranted the expenditure for the ponderous presses and die equipment required. In many cases, the adoption of stamping and drawing oftentimes involved radical changes in design, necessitating the employment of finer grades of steel and increased the number of operations, so that whereas the finished product was far superior to the old, the cost of production was considerably higher, and necessitated a correspondingly high selling price.

The introduction of the welding process, now universally recognized as an efficient method of joining metals, produced a gradual change in manufacturing procedure. Progressive manufacturers were quick to recognize the advantage to be derived from the elimination of rivets and lock joints, and the greater value of the product with the smooth, neat, (or, if desired) invisible seams produced by welding.

Many sheet metal products present insurmountable diffiiculties in their manufacture by the stamping method; some of these difficulties have been overcome by the use of the oxy-acetylene torch, and it is now being extensively used to unite stamped or drawn sections into a symmetrical and seamless whole. Some manufacturers have redesigned their product, in order to combine the advantages of the oxy-acetylene welding process with old seaming methods. There are numerous products which, due to their form and the service required of them, or for economic reasons, are a better product, by reason of this combination.

---

†Read before the New York Section, American Welding Society.
*Industrial Engineer, Air Reduction Sales Co.

The determination to manufacture by the oxy-acetylene welding method gives rise to the necessity for consideration of a number of vital points; gauge, preparation, cost, sequence of operations, jigs, finish of seam, and purpose for which article is to be used.

DESIGN

The problem of manufacturing is primarily one of design, and consideration must be given to every factor which might affect production. A number of designs must be worked out to provide for the most efficient operation, and the simplest means of handling. The application of gas welding is not different in this respect from any other manufacturing problem, with the exception that where hand welding is employed, there is seldom the same demand for exactness as when a mechanical operation is specified. There are, however, a number of points to be considered, all of which are important.

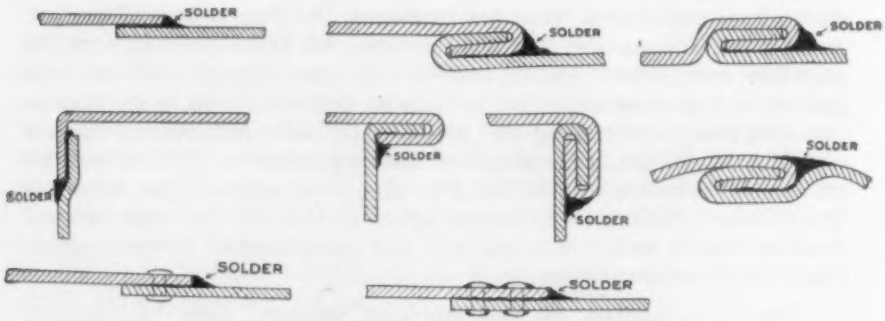


Fig. 1—Soldered and locked sheet metal seams.

The various types of welds which may be used, or required, must be considered, and the work planned to enable the operator to make the weld with the smallest expenditure of labor and gases.

We find a need for butt, lap, corner, spot, reinforcing and edge welds, in various types of production; each has its place, and preparation must be made so that the full value may be secured. See Fig. 2. It is often found necessary to employ several types of welds in the same part; this is frequently due to some peculiarity of construction, and in other cases may be necessary by reason of the service required of the article. Take, for example, the welded range boiler in which the longitudinal seam is butt welded, the joint between the head and shell lap welded, while the bottom and shell are edge welded together.

A mistake in design where welding is to be employed is a serious matter, and it is essential that the engineers responsible for the design confer freely with the welding department heads, or consult engineers experienced in the solution of all types of welding problems.

There are numerous instances of manufacturings designs incorporating various types of seams or joints in the same product. These designs are the result of long experience and have been adopted for economical reasons, or because there are providing reinforcing means of some kind, which gives the required strength to the weaker types of seams. In every case, the seam or joint subjected to the greatest strain is the one that is always welded.

Butt welds are the most common type of welds encountered; they are simple and easy to make. This is particularly true if the article is sylindrical in form and it is also true of edge welds.

Lap welds are seldom used, except in concealed positions, and principally in construction work where strength is not the main consideration.

Some manufacturers have combined both riveting and welding in the seam; the riveting operation being performed prior to the

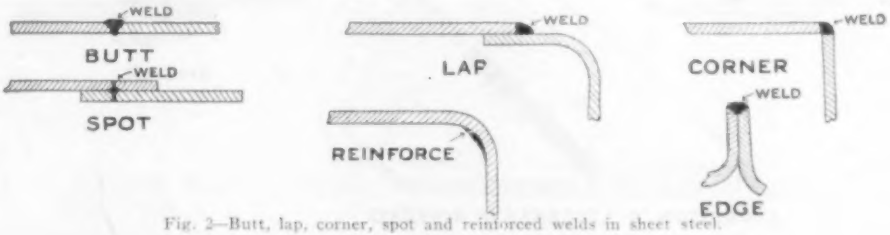


Fig. 2—Butt, lap, corner, spot and reinforced welds in sheet steel.

welding. See Fig. 3. This is a questionable practice, indicating a lack of faith in both operations; in fact, a large portion of the value of the riveted joint is lost, due to heat absorption, which tends to loosen the rivets and subjects them and the weld to an initial shearing stress. This is particularly true, in the lighter gauges, due to the proximity of the weld.

Reinforcing and spot welds are usually employed in connection with some mechanical method of joining, and are used to impart additional strength and stiffness. A good example of sheet metal production, employing welds of these types, is automobile metal body construction; here it is absolutely essential that there be no distortion, nor maring of the surface. The oxy-acetylene weld is admirable for this purpose, as it can be made of any dimension to impart the required strength or stiffness.

Strength

The adoption of sheet metal for the construction of vessels, containers, or parts for mechanical purposes, usually results in a product many times stronger than actually required to resist the tensile stresses to which they may be subjected. With this excess strength in the material, the oxy-acetylene weld employed in production welding with the usual reinforcement, is of sufficiently greater strength to insure full seam value.

In the welding of steel barrels, however, there are certain types in which deformation of the cylindrical shell is produced in order to get a stiffening effect, and in this operation the weld is stressed much beyond the elastic limit; even under such severe stressing comparatively few defective welds are found, and very few fail in service.

The production of welded steel containers include certain types which employ a combination of welded seams and bosses, while the heads and bottom are double seamed to the shell. This double seaming operation is an extremely severe test of the longitudinal weld. The first operation is the spinning of a half-inch flange on the shell a severe test in itself. The subsequent operations finally leave the edge turned inside out and rolled with tremendous pressure to permanently set the metal and leave a gas-tight joint.

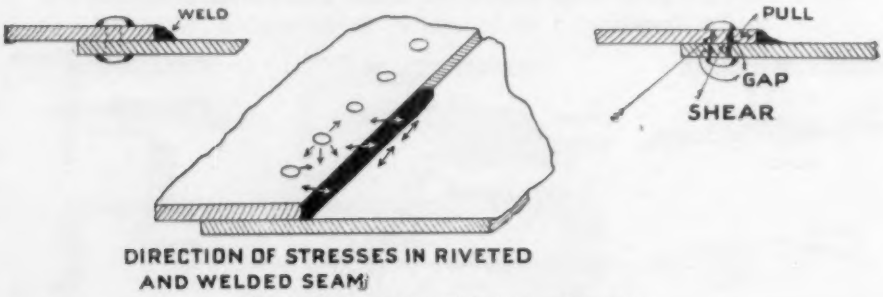


Fig. 3—Riveted and welded sheet metal seams.

The test required for the Interstate Commerce Commission of a welded steel barrel, which is given below, is a very severe test, and requires perfect welds of considerable strength and ductility:

Specification No. 5 requires a test of 15 pounds per square inch, with air under water, and a 40 pound hydrostatic test, in addition to dropping upon a concrete foundation from a distance of four feet when filled to 98 per cent of its capacity, without leakage. Specification No. 5A requires test of 15 pounds and 80 pounds respectively, and a six-foot dropping test, without leakage.

The manufacturer who decides that oxy-acetylene welding will play an important part in this scheme of production, does not face the necessity of providing a large plant area for the accommodation of expensive machinery. His production problems are often so simplified that the installation of comparatively few simple and inexpensive machines and jigs, will make possible a large production of fairly intricate sheet metal parts.

The welding equipment usually employed in manufacturing welding operation consists of hand welding torches which are obtainable in various types, and in several sizes. In connection with the torches there are required pressure regulators which reduce the line, or tank pressure, to that required for torch opera-

tion. Torches should never be operated unless the pressure is controlled by individual regulators, because uniformity of pressure is absolutely essential for efficient operation.

The acetylene gas supply in large installations is often derived from acetylene generators, which produce the gas direct from calcium carbide, automatically, as required. In installations of this kind the gas is distributed through pipe lines to the various welding stations.

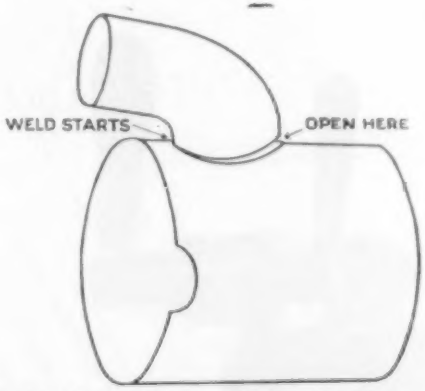


Fig. 4—Showing provision for contraction made when welding sheet steel muffler parts.

Numerous manufacturers avoid the expense of generator and pipe line installations, and resort to the acetylene cylinder containing dissolved acetylene for individual torch supply.

The oxygen for torch operation is derived from cylinders which may be used for individual torch supply, or connected in banks to a manifold, from which it is distributed through pipe lines at a pressure of from 25 to 50 pounds. At the individual welding stations, this pressure is reduced and controlled by sensitive pressure regulators to that required for the particular operation upon which the torch is used.

Perhaps the greatest application of the oxy-acetylene torch in production welding of sheet metal as examplified by a number of manufacturers, is in that class of production which employs a cylindrical shell, to which is attached heads or bottoms with filling or emptying outlets and connections, as well as means of handling. Under this heading would come steel barrels of various types, milk cans, ice cream cans, household utensils and kindred products. These products are of the simplest form, require only a simple type of equipment for production, are used in large quantities and require frequent replacement due to rough handling. These reasons account for the large number of manufacturers who are producing many thousands per day, each by a method peculiar to his plant and adapted to his machine equipment.

The successful production of sheet metal parts in large quantities is only possible when uniformity of shape and carefully planned jigs are provided which securely and accurately position the parts.

Jigs must be constructed so that the parts can be quickly placed and the finished product removed with despatch, and without distortion.

It is necessary that provision be made so that contraction and expansion stresses do not affect the accuracy of the jig or the welded product.

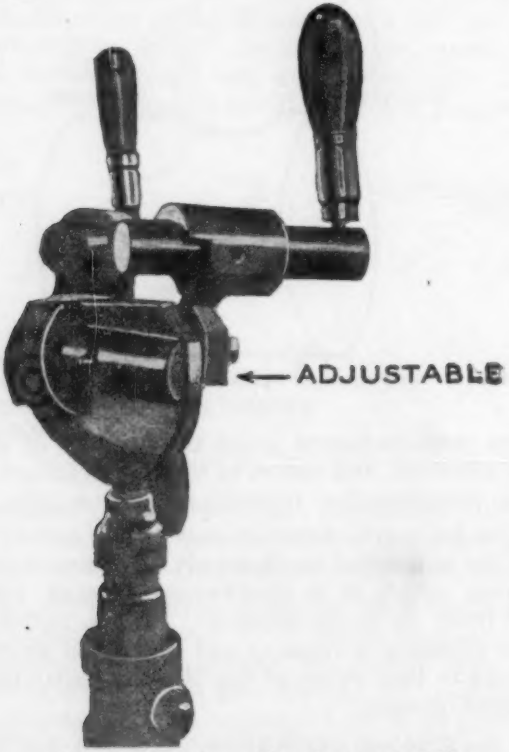


Fig. 5—Fixture for welding sheet steel muffler parts that provides for adjusment to suit each welder.

In the production of welded products which must line up accurately with and attach to machined surfaces or sections it is often essential to have the jigs adjustable within reasonable limits, and provision made for so holding the parts that when the contraction resulting from welding has taken place, the finished part will be true to gauge. See Fig. 4 and 5.

An important point to be considered, and one which will often require several trials to determine, is the place where the welding must start and finish, in order that extreme accuracy may be attained.

Few welders acquire the same motions, or are capable of welding at the same speed, and this again must be carefully considered and watched in jig welding operations, requiring accuracy in the finished product. Unless welders employed on work of this kind are all trained by the same supervisor, and the procedure of welding operation planned and adhered to, it is necessary that

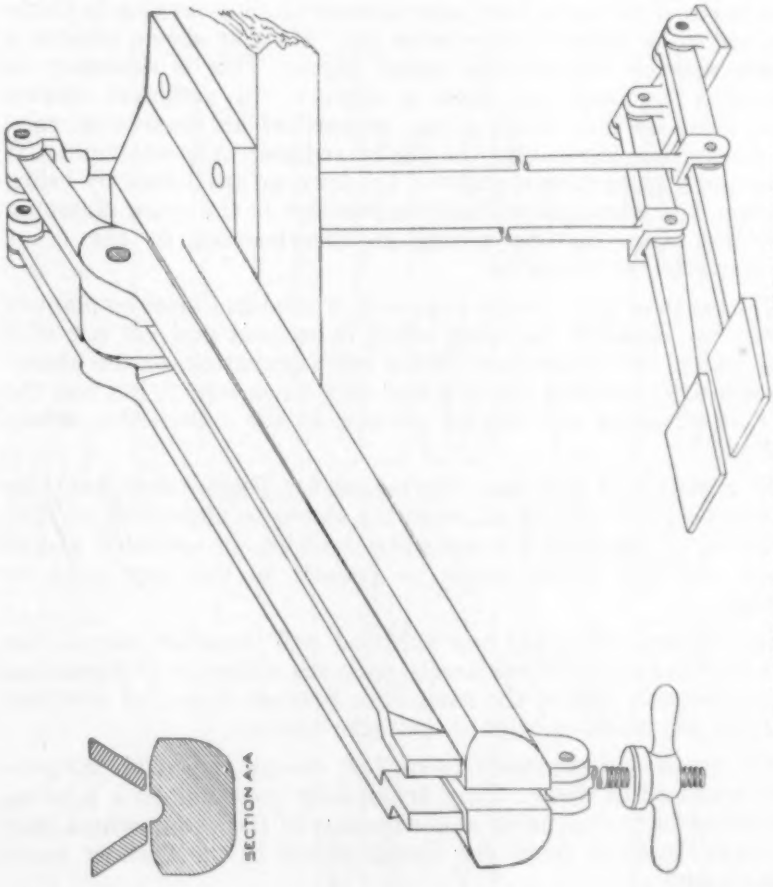


Fig. 6—Welding jig for steel barrels and other cylindrical containers.

each operator's jig be adjusted to his style and speed, and used by no other welder. The construction of jigs must be such that the clamping can be done quickly and with a uniform stress on the parts.

Distortion of the jig and parts must be avoided, unless the work is of such nature that distortion in a certain direction facilitates the welding operation, and counteracts a distortion which may be an after effect, due to the welding stress and the form of product.

The common form of welding jig for cylindrical work comprises a horn or anvil, properly shaped to hold the parts, and a

clamp of a form which provides a V-shaped groove with a slot exposing the seam to be welded. There are certain operations which require the clamping of the edges separately, and in this case the clamp is divided so that the positioning of each arm can be a separate operation. See Fig. 6. This type of jig is often made so that the space between the clamping edges can be varied. Theoretically, this feature is essential for economical operation when parts of the same form and dimensions, but varying in thickness, are to be welded in the same jig. Heavier sheets require a greater spacing between the clamp edges. This is necessary in order that the flame may come in contact with sufficient surface of the sheet so that welding may proceed at an economical rate, and conducting losses into the jig be reduced to a minimum. It is necessary to provide a space in the horn or anvil directly below the seam, and when adjustability is provided in the upper clamping arms the same feature should be incorporated in the other for most efficient operation.

The depth of the V-shaped space is critical and must be planned so that the required clamping effect is secured and yet not of a depth which will interfere with the torch operation, or the vision. An excessive clamping effect is not only unnecessary, but has the effect of stressing the welded portion as the contraction strain accumulates.

As a matter of fact, the only reason for jigging is to hold the parts in position and the edges of the sheets in alignment, so that absorption of the heat will not cause buckles, or wrinkles, and to smooth out any which might be present in the part prior to welding.

A jig properly designed and adjusted will therefore permit the parts to move more or less freely with the influence of expansion and contraction, and at the same time prevent improper positioning from the afore-mentioned, or other causes.

The types and construction of jigs are as varied as the products produced in them . They are usually the result of a gradual development and expansion of the process in the plants where they are found, most of them are ideally suited to the product made by their use.

Few, if any, hand welding operations require water-cooled jigs, and if used they detract from the speed and economy.

Manufacturers whose product is mainly sheet metal parts requiring steel from 15 to 12 gauge in thickness, and of a more or less cylindrical form, do not use jigs to any great extent, preferring to put the labor required for jigging into more accurate forming, and often by a simple tacking operation insure proper positioning of the edges, preparatory to welding.

There is always a doubt as to the wisdom and economy of this method, and it would seem certain that compared with similar

operations carried out in jigs, the result would be in favor of the latter method.

Practically all hand welding operations require the addition of metal in the production of the welds. This is necessary because an operator cannot hold his torch with sufficient steadiness to insure neat work, and the addition of metal to the seam increases

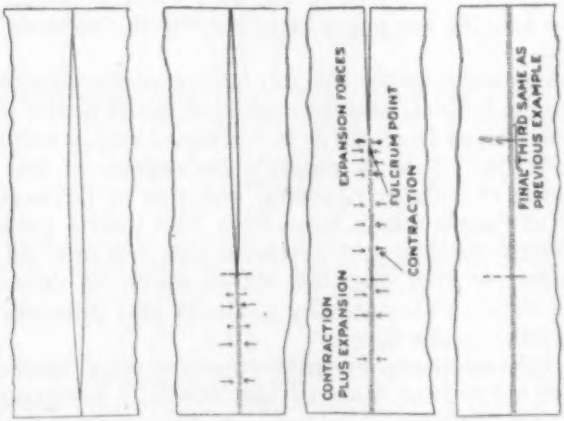


Fig. 8—Welding concave sheared edges in sheet metal.

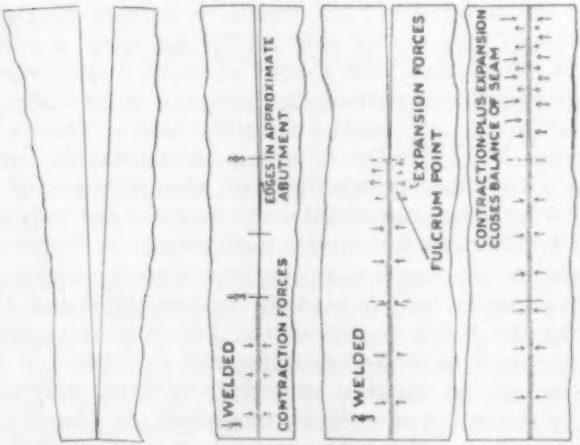


Fig. 7—Welding straight sheared edges in sheet metal.

the tickness sufficiently, as that more latitude in torch operations is permitted, with the additional advantage of increased strength in the welded portion of the product.

Welders have their own pet methods of torch and welding rod manipulation, and while the elimination of lost motion, the use of the proper size of welding wire and welding tips would show economies, the results obtained are, as a rule, satisfactory.

As a matter of fact, it is far more important to use adding material of the proper quality, and control the mixture of gases accurately, than it is to prescribe the motions which shall be given the torch in weld production.

Many sheet metal products now being manufactured by the oxy-acetylene hand welding method, are being adapted to mechanical gas welding. In fact, it is becoming an actual necessity because the demand is increasing so rapidly that in some cases if this method were not adopted, additions to the plants would be necessary to provide the space required for the welders and welding stations.

Mechanical welding by the oxy-acetylene process with properly designed machines, and accurately formed parts, makes possible a production of from three to ten times that possible by hand welding methods. This is possible by reason of the ability to employ torches of greater capacity, and tips or burners having a mutliplicity of flames which spread the heat over a greater length of seam. These torches and powerful tips can only be employed in combination with a machine whose speed is under accurate control, and which automatically positons and presents the seam in proper relaton to the torch.

The mechancial operation of the oxy-acetylene torch is usually in connection with some more or less specially designed machine, adapted to some specific operation. In other words, most of the machines in operation are what might be termed single purpose machines, in that they do not provide for universal application in welding all sizes, gauges, and shapes of sheet metal products.

The usual practice is that of clamping the work and holding it stationary, while the torch moves along the seam. This is the more simple method, but in order to secure a reasonable production, it is necessary to employ more than one clamping or jig member, and means for relative movement must be provided between these members and the torch traversing mechanism.

A machine, or mechanism, properly designed, can be operated at maximum capacity by one man, if the positioning of the edges in relation to the torch is automatic, but this can only be accomplished through accurate shearing and forming.

The clamping or jigging principle differs very little in mechanical welding, from that employed in hand welding. Elaborate methods have been employed in particular instances, even to the extent of automatically positioning a flat sheet forming to shape, clamping in position and welding all in what might be termed a single operation. There are instances of intricate mechanisms for torch motion and gas control automatically operated; in some cases in combination with the simplest type of work support and clamping mechanism. The idea back of all this is economy, but as a matter of fact excessive refinement in operation calls for extreme accuracy in preparation, and does not permit adjustments for the variables which are always present.

In the mechanical operation of the welding torch as applied to the welding of a long straight seam, there is presented a problem not present in hand welding operations. This is the problem of co-ordinatng the rate of welding, the complete fusion of the edges, the expansion, and the resulting contraction.

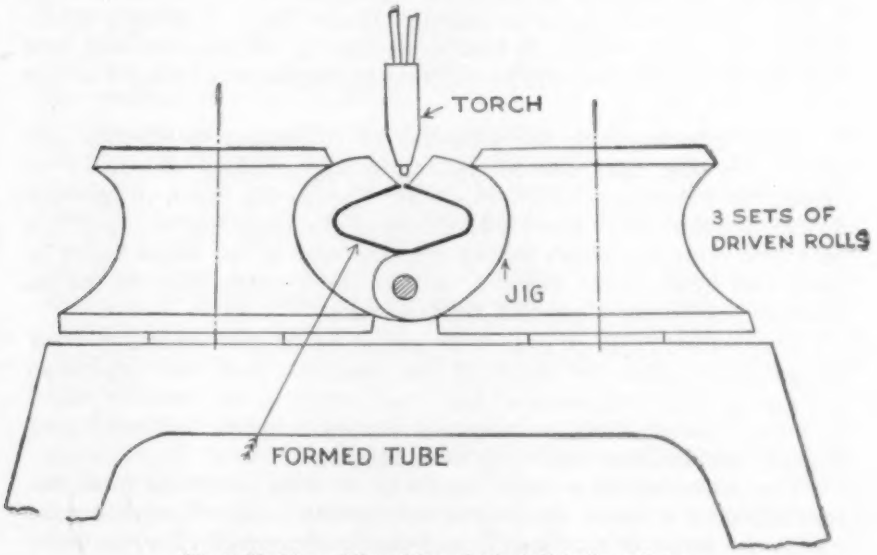


Fig. 9—Machine welding of formed tube held in jig or fixture.

Two methods are in vogue, one requires absolutely straight sheared edges, so that when the edges are placed together they will be in abutment throughout their entire length. For this method, the clamping or jigging mechanism must grip the metal firmly at the point where the weld is to start, and with just sufficient pressure at other points to insure juxtaposition of the edges.

Assuming that the proper speed has been determined upon, and the correct adjustment of the gas and oxygen pressure made for this speed, it is then necessary to spread the edges apart at the finish of the weld, a distance which at this predetermined speed will permit the edges to move freely to and fro under the influence of the heat, and finally come together when the torch has almost completed the weld. See Fig. 7. The proper spacing of the edge when determined is controlled by a properly positioned gauge. The behavior of the edges during the welding operation under these conditions is quite uniform, and very interesting. For about one-third of the distance across the seam, the edges gradually move together and are practically in abutment, with only a very slight movement of the edges at the extreme end; as the torch progresses the edges now move together throughout the remaining length of the seam until the torch has traversed about two-thirds of the seam. Now, if the original spacing was correct, the edges

will rapidly spread for an instant, and again come into gradual abutment as the torch completes its movement along the seam, resulting in a perfectly welded seam.

The other method requires less care and preparation, but is applicable only when extreme accuracy in dimensions is not required. It consists in shearing the edges of the sheet so that when formed and placed in position in the jig or clamping mechanism, the edges will be in abutment only at the extreme end, and the clamping effect should be uniform throughout the length of the seam.. See Fig. 8.

With this method, the behavior of the edges is slightly different, in that they are brought into approximate abutment by reason of the expansion effect of the heat as the torch progresses along the seam, until about two-thirds of the seam has been welded, at which time the edges at the extreme end of the seam begin to open and again come together as the torch completes its travel, thereby producing a perfect welded seam.

A constant ratio of gap to length of seam may be utilized for all gauges within the range of the machine, and the expansion or closing effect conpensated for by a change in the welding speed and gas consumption, or where a constant speed is maintained the gas consumpion only may be changed.

The manufacturing and machine welding methods just described, do not have the production possibilities of machines in which the torch is stationary, and the work moves. In machines of this type, there is little if any time lost between the finish of one operation and the beginning of the next. See Fig. 9. Formed parts are mounted in jigs, and the jigs moved through the machine at a constant rate, provision being made in some cases for automatically positioning the torch with reference to the seam in order to meet peculiar conditions.

Production by this method introduces the ability to produce welds which are a combination of fusion and compression. This is accomplished by the use of jigs which are more or less flexible, while in some cases the pressure is applied directly to the sheet metal part which is being welded.

There is no better known machine working on this principle, than the conventional Tube Welding Machine, of which there are approximately two hundred and fifty in daily operation in this country, producing over half a million feet of gas welded steel tubing in a nine hour day.

This type of machine construction lends itself readily to the utilization of jigs for holding tubular sections, which may be of round or other shapes, and of very short lengths.

Welds made under the influence of fusion and pressure have greater strength than hand welds of the same section or mechanical welds made by fusion only. Considerable attention is being given to this type of mechanical gas welding, and the adaption of many products to this method is at present under way.

Little, if any, effort has been put into the development of making circumferential welds mechanically by the oxy-acetylene process.

This is not because it is impractical, but largely because manufacturers will not put the necessary effort into the production of parts sufficiently accurate for this type of welding operation. Then again it requires more complicated jigs and machines to successfully produce welds of this type. This is largely due to the fact that the positioning of the edges and the equalization of the stresses is more difficult.

The subject of oxy-acetylene welding in all its phases, is one worthy of the attention of the most important officials in any company. The process is so simple, and its introduction into a plant so readily made, that the benefits to be derived from its most scientific application are often times overlooked. Oxy-acetylene welding is not an incident in the manufacture of sheet metal products, it is more often the process which makes economical production possible, and should therefore be given the same consideration that is usually given to mechanical manufacturing methods.

The next few years will see great strides made in the application of gas welding, and particularly the automatic or mechanical application of the process. This is a natural and necessary development, and one which is being brought about by the demand for more and more production. The elimination of the human element, and the ability to depend with absolute assurance on a continuous production of uniform quality, with a minimum of supervision, is an accomplishment the attainment of which is worth all the thought and effort required.

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WELDING OF NON-FERROUS METALS

By C. J. HOLSLAG†

The welding of non-ferrous metals and the welding of thin iron plate are very similar, i. e., the problem is that there is no viscous point, the metal is either solid or fluid, and when fluid, unless exactly horizontally level and backed up by some heavier, colder piece, will melt and run away.

If the pieces to be welded are backed up by the heavier metal piece, or if they are in a trough shape with the "V" of the trough at the bottom, welding with the electric arc is very easy by ordinary methods, but various arrangements must be provided in order to keep the fluid parts from running out of place. The simplest and most effective arrangement is as shown in Fig. *a*, the adjustment of two plates, i. e., copper, aluminum, bronze, brass, or thin sheet iron being so arranged that there are two vertical abutting edges. The arc, whether from a graphite electrode or from a metal electrode similar to the plates to be welded, is then run rather rapidly along this edge, melting the two vertical edges together into a single bead as shown at *b*.

Copper tanks, thin sheet water jackets and many other uses allow electric welding to be applied to these jobs. Welding entirely automatic has been done in this manner, simply passing the edges at an even rate under the arc.

Fig. *d* shows the method of two overlapping plates. The arc being held mostly from the upper plate, as shown at *e*, allowing the underplate to serve as the recipient of the molten bead. In welding with the graphite arc there is the choice of the single graphite rod with the work as one electrode, as shown at *b*, or of the double graphite, or carbon arc, as shown at *c*, with the work under any part of the electrode.

These two methods offer distinct solutions for various jobs in that the single graphite method is similar to metallic electrode, and on pulling away the heat in the arc is increased, due to the voltage having increased across the arc. This, on thin work or non-ferrous metals, generally results in a hole or a burned spot. With the method shown at *c*, the action is similar to that of the gas torch, i. e., the flame can be pulled away from the work and the amount of heat supplied to the work lessened, the heat being constant and the amount supplied to the work being in direct proportion to the distance of the flame from the work. This allows of thinner and more delicate work being accomplished than the other method, and allows of two plates being floated together more delicately than with the single electrode method.

As shown in Figs. *f* and *i*, a separate filler electrode can be used

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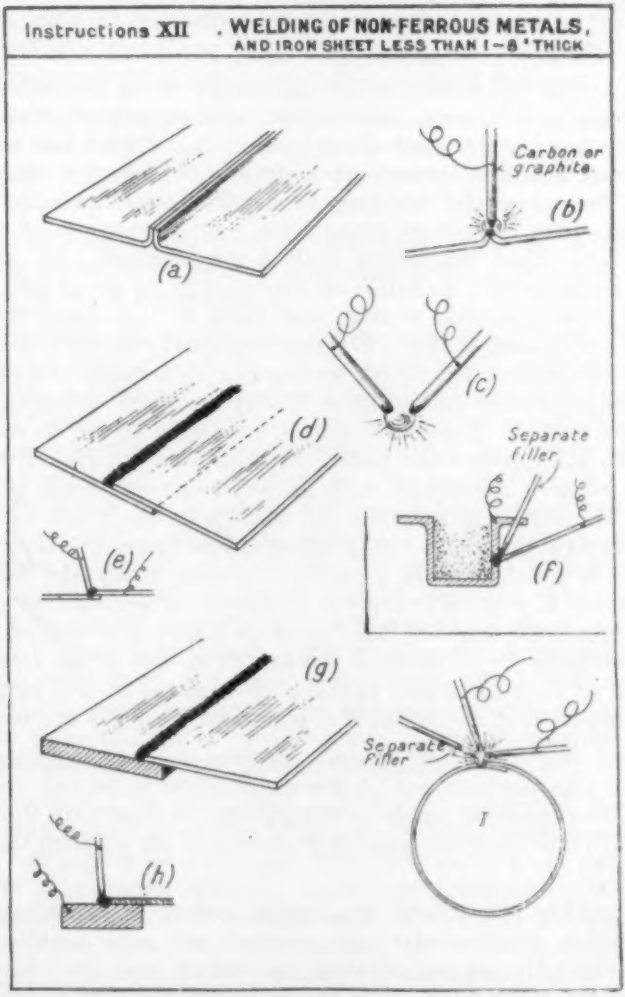
* Taken from Handbook to be published by the McGraw Hill Book Co.

as with a gas flame by either the single graphite or the double graphite arc. Fig. *f* shows the method of welding aluminum crank case with the inside of the crank case moulded around the spot to be welded with plastic asbestos, which serves to keep the original shape of the crank case while the aluminum is fluid, i. e., aluminum



has no well-defined viscous point as has steel. Aluminum, copper or bronze in general require a mould of plaster of paris or asbestos to be made to keep the metal from flowing away after being melted by the arc, unless work is so thick that it serves as its own backing. Figs. *g* and *f* show method of applying a small section to a larger one. Here the metal electrode can be used successfully, the arc being drawn mostly from the large section, carefully watching the edge of the lighter section to see that it does not more than flow into the puddle made in the larger section.

Preheating. Welding of non-ferrous castings, as well as cast iron, requires the use of preheating, reheating and annealing depending on the job and the results desired. This preheating can be done by gas or oil torches, or by an electric preheater, with an electrode larger than for welding thin work. The preheating sometimes is only necessary at the spot to be welded, and other times the whole casting must be preheated to even out the strains resulting from welding.

In the welding of bronze, brass and monel metal and other non-ferrous alloys, and in some cases copper and aluminum, the metallic electrode can also be used directly, that is, without the addition of heat from a single carbon or a double carbon arc as in gas welding. The successful welding of brass depends mostly on its zinc content, that is, yellow brass with a high content of zinc is harder to weld than red brass with a low content. In welding bronze or brass with a metallic electrode, it is of great aid to get it hot from some outside source, and weld at the speed that the metallic arc will keep it hot. There is one electrode that will weld all non-ferrous metals for repair to meet rustless requirements and that is a nickel-manganese copper electrode which deposits practically monel metal. This combination of nickel seems to combine readily with all non-ferrous metals as well as with cast iron. If no outside alloy is allowable, such as welding new work, the best rod to use is what is most generally known to the trade as Tobin bronze, although there are many other trade name bronzes which are equally as good, and, in general, are practically the same as Tobin bronze. If you have a piece of bronze either cast or drawn (drawn is generally better) and want to know if it can be made use of for welding try it through the arc, or if this is not available, heat an end of it red hot and hammer it to see if it will forge out flat or crumble. If it crumbles, it is practically useless for welding.

The safest way is to buy one of the flux-covered welding rods designed for this purpose, which are guaranteed to be satisfactory, and generally represent years of experience in obtaining the right analysis and right drawing and skin condition for passing through the arc.

Welding yellow brass with the single carbon is practically out of the question because the zinc content not only liquifies, but vaporizes before the copper content has melted, and the white zinc oxide covers the work with a film through which welding cannot be accomplished.

With the double carbon arc, however, the heat can be held sufficiently far enough away from the brass to allow the entire surface to melt, including the zine and tin. The action is similar to the brazing of cast iron, only the brass and bronzes have the high copper heat conductivity. To overcome this heat conductivity partially, wet plastic asbestos or some other means of water cooling can be mounted near the vee. The action in welding brass is

similar to brazed cast iron or any metal. First, be sure that the edges and bottom are coated with the filler. In other words, make sure that the solder sticks. If the job is a long one, 3″ or 4″ could be coated at a time, after which there is no trouble in filling in, providing the flame is kept far enough from the job so as to not oxidize the zinc content. Also, when the job is filled up, even if it looks a little rough, there is no sense in playing the flame over it as it will become more and more spongy by this action. If the surface must be finished, machine it or grind it smooth.

To recapitulate, the best chances of success in brass welding or brazing lie in getting the metal to be welded impregnated with the filler rod, before filling in; in other words, tinning the edges the same as in soldering.

Another precaution is when the layer is partly filled up, don't play the flame on it until it is spongy looking, but add more filler and go on with the welding.

The welding of copper—as might be inferred from the previous talk about copper and zinc content—is much simpler than brass or bronze, although bronzes containing a great portion of copper are practically equivalent to copper as regards welding. There is only one criterion as to whether the copper job can be successfully welded, and only one method to use in welding it. This prerequisite is that the copper be red hot or very nearly red hot before starting to weld. At this temperature copper can be welded with the single or double carbon arc, or with the metallic electrode. Here, again, water-cooling by wet asbestos or other means will aid in keeping the heat from disseminating. Copper, as you know, has the highest heat conductivity of any of the metals we meet in welding, and there are some heavy jobs which require a deal of heating, but copper objects are generally costly, enough to allow for the extra charge of coal or other means of heating to be more than counterbalanced in the saving effected.

The welding of lead, zinc and tin is described in this paper under the heading of "Welding or Burning with the Conducting Arc." It might be said here that the welding of galvanized objects is exceedingly difficult unless the galvanizing is burned off. Galvanized steel can be welded with the electric arc as the heat of the arc seems to vaporize the zinc out of the metal ahead of the arc, although there is a great liability of pin holes due to the escaping gases through the weld. If the metal is thick enough, such as galvanized tanks so that extra heat can be used, there will be no trouble getting rid of the zinc as you weld.

The welding of aluminum is a very complicated process, and either a man should have three hands, or use a helper. The aluminum must be puddled while in a viscous state in order for the filler rod to unite the crack or joint. The sources of heat, be it single carbon arc or double carbon arc, must be so softened on

edges so as not to make the metal fluid but just reach the viscous point. A great aid also is plastic asbestos along the edges or crack of joint, or in back of the joint as a sort of mold so that not only will the heat disseminate less, but should the metal become too hot, it will not flow away and ruin the job, but allow the metal time to cool back to a viscous stage. After the trick of reaching the viscous point is attained, an iron spoon such as 3/16″ electrode flattened out one end to 3/8″ is used to puddle the metal about and remove the oxide so that the silver metal can unite with the filler rod, which is preferable accomplished by approaching the arc with the filler rod and letting the molten end drop off. This method, by the way, is the best method to use in all carbon arc welding. Let the flame heat, melt the filler rod—in no case laying the filler rod on the work and melting it with the heat later, as this is very liable to result in big gobs of the filler rod not being melted into the parent metal.

The metallic arc welding of aluminum would be an ideal method as aluminum is liable to warp and crack even when packed with asbestos, but so far there has not been developed a metallic aluminum electrode which has been commercially successful except on heavy work.

The use of monel metal and other nickel alloys involve other problems, and in this case, the International Nickel Co. have made extensive developments for their customers, and they gave the results to the trade, which, in substance, are as follows:

Use a flux to prevent oxidization of the metal. Flux-covered nickel of approximately the same analysis as the metal to be welded must be used for good results. The weld should be made in one layer as speedily as possible, in other words, as little heat as is possible to weld up in the metal, as monel metal has a greater coefficient of oxidization and is more liable to warp out of shape than any metal we have thus met in general. However, monel metal will not crack in warping, and if the main contour is held by clamps approximately shaped around, the weld can be forged with a hammer.

The best method to use in electric welding monel metal is the metallic arc with the proper flux-covered electrode—monel can be welded with the single or double carbon arc. In welding monel metal, aluminum or brass of zinc content, it is preferable on D. C. to make the work negative instead of positive, while on A. C. the work and the electrode are always neutral and no polarity prevention need be observed.

As aforesaid, an alloy electrode of Nickel-Manganese and copper will weld all nickel alloys besides cold cast iron producing in the latter machineable welds.

Welding or Burning with a Conducting Arc

Lead burning either together of sheets or lugs on or off is entirely possible with the contact arc. The method is to obtain a

source of 60 to 100 amperes at 8 to 15 volts and simply attach one of these leads to one terminal and the other to a holder for a small carbon ¼″ or ⅜″ in diameter and 6″ to 12″ long with end sharpened like a small cutting chisel. Upon touching this electrode to the lead in a few seconds the end will glow white hot and the lead will melt and can be worked while in a semi-viscous stage. The current can be adjusted by the length of carbon (not graphite for this work) protruding from the holder or by the supply voltage. A transformer type welder gives easy gradations of voltage for this purpose.

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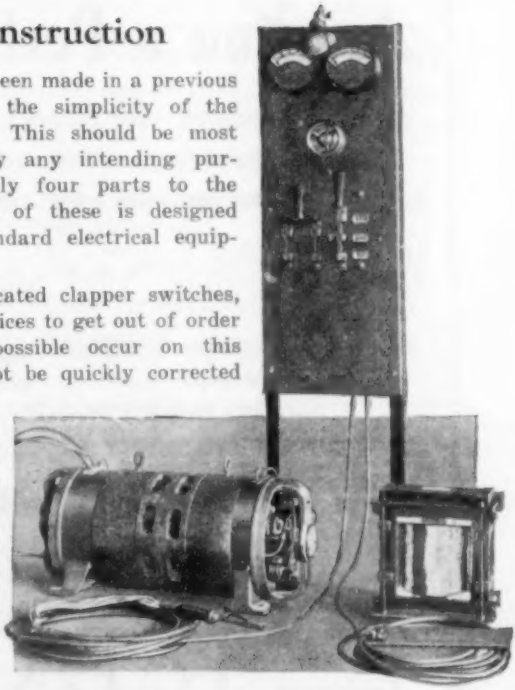

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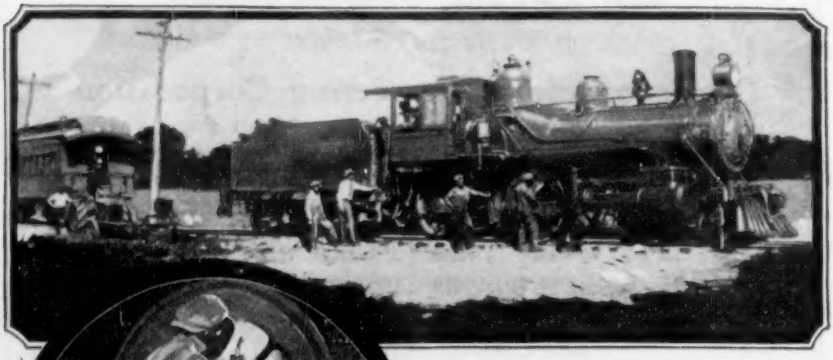

This is a drawing from an actual photograph showing the broken frame of a locomotive that is being repaired with a Westinghouse arc-welding outfit — not in the shops but on the right-of-way

Electric Welding

Saves Time — Money — Material

A broken frame stopped this locomotive and threatened a trip to the shops, a disorganized schedule, a long delay for passengers and express matter, and a cost that would have been very serious.

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After that, it was only a matter of a few hours till the train was on its way again; the frame *permanently* and *properly* repaired by a portable welding set which had been operated by the same tractor that drew it out from a nearby town. Just think about that a minute!

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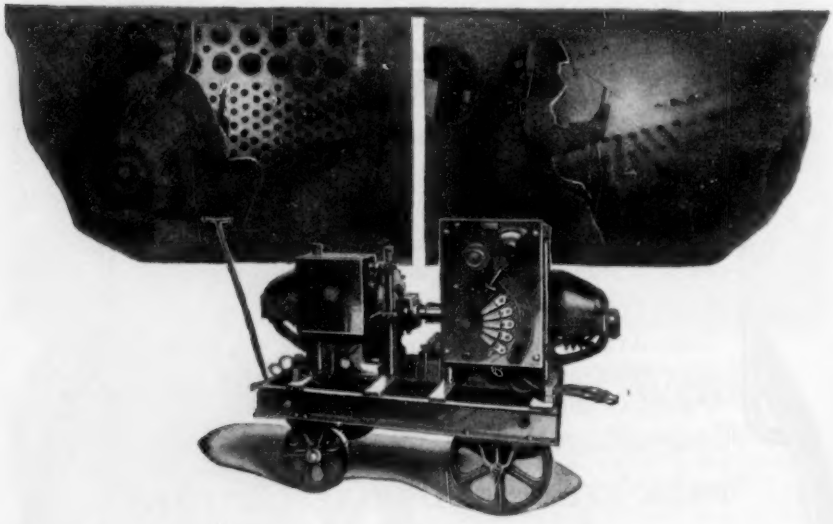

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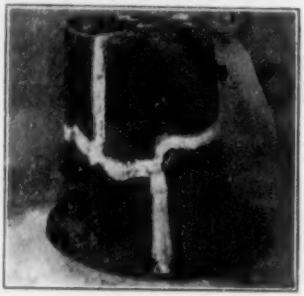

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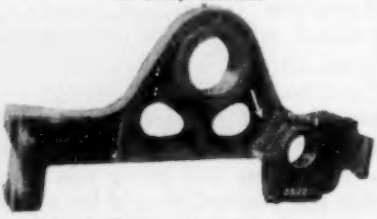

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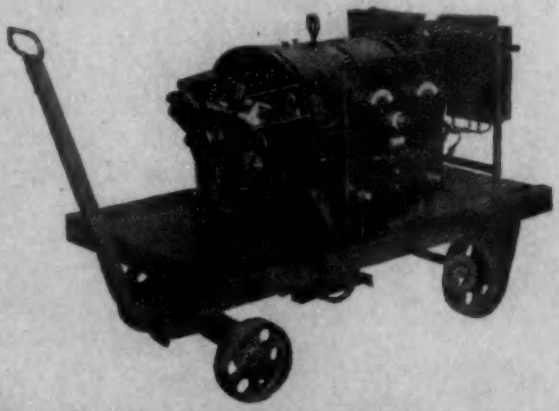

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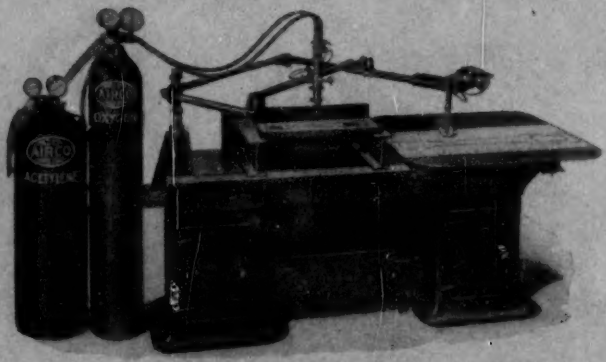

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